Chemical Vapor Sensing in Monolayer MoS_2

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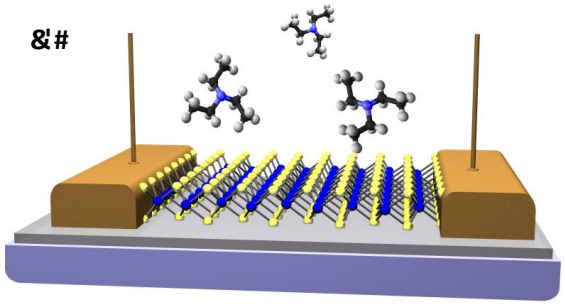
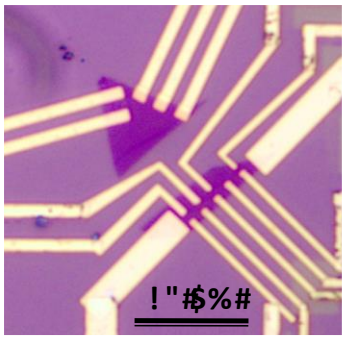
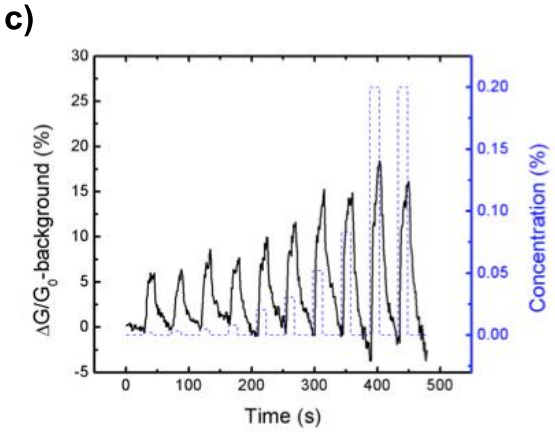
Two-dimensional (2D) graphene, although it has many remarkable electronic properties, is chemically inert. Therefore, it does not easily lend itself to chemical sensing applications. However, MoS_2, a 2D dichalcogenide of recent interest because of its potential for transistor applications, possesses many advantageous properties for chemical sensing. Two primary examples include a sizable bandgap, which is necessary for fabricating transistors with large on/off current ratios, and a chemically reactive surface, which is necessary for easy surface functionalization. In the past, these properties have been exploited by the oil industry by using MoS_2 platelets in hydrodesulphurization reactions, suggesting that MoS_2 films are indeed reactive and/or can catalyze chemical reactions. In this talk, we discuss our current research effort on MoS_2 chemical sensors[1]. We discuss aspects of transistor device fabrication and chemical sensing experiments. We expose MoS_2 chemical sensors to a variety of analytes, finding the best response to triethylamine, a nerve gas by-product, and explain our results based on a donor-acceptor model. MoS_2 sensors are compared to other similar low-dimensional sensors such as carbon nanotube and graphene chemical sensors and found to be of comparable quality. In the future, we envision suites of 2D materials[2], each suited to selectively sense certain chemical compounds, that together will comprise a sensitive, full-spectrum chemical sensor that is ultra low-power, physically robust, and inexpensive.







a) drawing of a MoS2 sensor device b) optical image of an MoS2 sensor device, c) MoS2 sensor device responding to increasing pulses of triethylamine. The device response is in black and the pulse sequence is in blue.

References

[1] F. Keith Perkins, Adam L. Friedman, Enrique Cobas, Glenn G. Jernigan, Paul M. Campbell, and Berend T. Jonker, "Chemical Vapor Sensing with Monolayer MoS_2," *Nano Letters*, vol. 13, no. 2, pp. 668-373, 2013.

[2] Adam L. Friedman, F. Keith Perkins, Enrique Cobas, Glenn G. Jernigan, Paul M. Campbell, and Berend T. Jonker, "Chemical Vapor Sensors Using MoS_2, Carbon Nanotubes, Graphene, and Other Low-Dimensional Materials for a Full Spectrum Sensor." US Patent Pending, case number 102415. Filed March 16, 2013.